PART 2

DESIGN CRITERIA FOR STORM WATER MANAGEMENT SYSTEMS

This section sets forth specific design and construction standards that will be used by the Drain Commissioner in review of proposed storm water management systems in accordance with the objectives of managing both the quantity and quality of storm water runoff. A Glossary of Terms used throughout this section is provided in Appendix A.

It is difficult or impossible to develop one set of uniform standards that is capable of accommodating all variables and unique site circumstances. In particular, it is recognized that these standards may be difficult to realize on small sites. Waivers or variances from specific provisions of these standards may be requested, and alternatives consistent with the overall intent of storm water quantity and quality management may be proposed, subject to the approval of the Drain Commissioner.

Whereas basin design for flood control is concerned with capturing and detaining relatively infrequent, severe runoff events, such as the 10-, 25-, or 100-year storm, designs for water quality control require that the more frequent storm events (e.g. 1.5-year storm or less) must be addressed as well. The need for managing smaller storms is directly related to urbanization within Washtenaw County and the accompanying increase in impervious area, which affects surface water quality in two important ways.

First, eroded soil and other pollutants that accumulate on impervious surfaces, such as metals, fertilizers, pesticides, oils and grease, are flushed off by the early stages of runoff, which then carries a shock loading of these pollutants into receiving waterways. By capturing and treating the first 0.5-inch of runoff, pollutants that are washed off of the land can be removed from storm water before it flows offsite.

Second, as recent studies by the MDNR have shown, development within the County has caused stream flow fluctuations to rise dramatically. As impervious surface area increases and opportunities for infiltration are reduced, the frequency and duration of bankfull flow conditions, typically represented by the 1.5-year storm event, have intensified. As a result, streams adjust their capacities to convey the increased flows, leading to channel and bank erosion and the destruction of aquatic habitat.

To manage both water quantity and quality, basins must be designed to capture and treat three different storm events:

1. The 100 year storm event
2. The bankfull flood; the 1.5-year/24 hour storm event
3. The first flush volume; the runoff from the first 0.5 inch of rain from the entire contributing watershed

Controlling both extremely large events, to prevent flooding, and more frequent events, to mitigate water quality impacts and channel erosion, can be achieved through the proper design of detention/retention basins. Among alternatives, wet ponds and constructed pond/wetland marsh systems are the most effective for achieving control of both storm water volume and quality. Extended detention ponds providing two-stage pond designs that contain an upper, dry stage and a lower stage with a permanent pool are also acceptable, though their ability to

remove critical pollutants such as total phosphorus is limited. Dry ponds providing extended storage will be accepted only when the site's physical characteristics or other local circumstances make the use of a wet pond infeasible, or when thermal impacts are a primary concern.

The phosphorus removal capability of wet ponds, wet extended detention ponds, multiple ponds, pond/wetland marsh systems and infiltration systems is superior to other BMPs. This is of particular importance in a geographical area designated as the "Middle Huron River." This area, extending from Sylvan Township at the County's western boundary, through Ypsilanti Township on the east, is under a Total Maximum Daily Load (TMDL) limit by the Michigan Department of Environmental Quality (MDEQ). This limit requires the reduction of current phosphorus loadings to the Huron River by 50%. See Appendix C, Special Areas of Concern.

Extensive literature is available on specific design concepts and alternatives, and selected references are available within this document's appendix. Diagrams for a number of these concepts are contained within Appendix D. Several other structural Best Management Practices (BMPs) not referenced within the following text are also illustrated.

Individuals seeking to develop land within Washtenaw County are encouraged to contact local governments regarding their local storm water BMP requirements. Standards in addition to those contained in these rules may be in effect in specific communities or creeksheds.

I. STORM WATER DISCHARGE

A. In no event will the maximum design rate or volume of discharge exceed the maximum capacity of the downstream land, channel, pipe or watercourse to accommodate the flow. It is the proprietor's obligation to meet this standard. Should a storm water system, as built, fail to comply, it is the proprietor's responsibility to design and construct, or to have constructed at his/her expense, any necessary additional and/or alternative storm water management facilities. Such additional facilities will be subject to the Drain Commissioner's review and approval.

B. A description of the off-site outlet and evidence of its adequacy is required. See Appendix Q, Engineer's Certificate of Outlet.

C. If no adequate watercourse exists to effectively receive a concentrated flow of water from the proposed development, discharge will be reduced to sheet flow prior to exiting the site. Further, if the proposed storm water management system cannot achieve pre-development conditions, with respect to both volume and rate of storm water runoff, it is the responsibility of the developer to secure necessary easement(s) from downstream property owner(s). See Appendix T.

D. Discharge should outlet within the drainage basin where flows originate, and generally may not be diverted to another basin.

II. DETERMINATION OF SURFACE RUNOFF

A. The rational method of calculating storm water runoff is generally acceptable for highly impervious sites less than 120 acres in size. However, it may not be considered an adequate design tool for sizing large drainage systems. All composite

runoff coefficients shall be based on the values shown in the table below. The slopes listed for the semi-pervious surfaces are the proposed finished slope of the tributary area.

Table 1. Minimum Acceptable Runoff Coefficients for use in Rational Method

Type of Surface	**Runoff Coefficient**		
Water Surfaces	1.00		
Roofs	0.95		
Asphalt or concrete pavements	0.95		
Gravel, brick, or macadam surfaces	0.85		
Semi-pervious; lawns, parks, playgrounds	Slope <4%	Slope 4%-8%	Slope >8%
Hydrologic Soil Group A	0.15	0.20	0.25
Hydrologic Soil Group B	0.25	0.30	0.35
Hydrologic Soil Group C	0.30	0.35	0.40
Hydrologic Soil Group D	0.45	0.50	0.55

B. More precise methodologies for predicting runoff such as runoff hydrographs are widely available, and may be required by the Drain Commissioner for sizing the drainage systems on large sites and/or smaller sites that are deemed potentially problematic. Acceptable alternative methods include:

1. U.S. Army Corps of Engineers HEC-HMS, HEC-1
2. Natural Resources Conservation Service UD-21, TR-20 and TR-55
3. U.S. EPA's SWMM
4. Continuous simulation (HSPF)

C. Unless a continuous simulation approach to drainage system hydrology is used, all design rainfall events will be based on the SCS Type II distribution.

D. Computations of runoff hydrographs that do not rely on a continuous accounting of antecedent moisture conditions will assume a conservative wet antecedent moisture condition.

E. For sites with upstream watersheds equal to or greater than 2 square miles, approval of the MDEQ is required, pursuant to Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. The MDEQ will compute the runoff rates at no charge. The MDEQ requires applicants to use the UD-21 method by SCS in lieu of the rational method. This method was developed for small watersheds by SCS, and can be used for watersheds up to 10 square miles. Computer programs such as HEC-HMS, HEC-1 and HEC-RAS, DEQ permit applications, and other relevant information, can be downloaded from the MDEQ web site. See Appendices I and J for more information.

RETENTION AND DETENTION SYSTEMS

A. General Requirements

All runoff generated by proposed impervious surfaces must be conveyed into a storm water storage facility for water quality treatment and detention/retention prior to being discharged from the site. The following criteria will apply to the design of all storm water retention and detention facilities.

1. Wet ponds and storm water marsh systems will be preferred to dry ponds. Dry ponds providing extended storage will be accepted only when the development site's physical characteristics or other local circumstances make the use of a wet pond infeasible.

2. Public safety will be a paramount consideration in storm water system and pond design. See PART 2, Section XII. Providing a safe design for storm water storage is the proprietor's responsibility. Pond designs will incorporate gradual side slopes, vegetative and barrier plantings, and safety shelves. Where further safety measures are required, the proprietor is expected to include them within the proposed development plans.

3. For safety purposes and to minimize erosion, basin side slopes will not be steeper than one-foot vertical to five feet horizontal (5:1). Steeper slopes may be allowed if perimeter fencing at least 5 feet in height is provided. In general, the side slopes shall not be flatter than one-foot vertical to 20 feet horizontal (20:1).

4. Detention and retention facilities shall be located on common-owned property in multi-ownership developments such as subdivisions and site condominiums, and not on private lots or condominium units.

5. Adequate maintenance access from a public or private right-of-way to the basin will be provided. The access will be on a slope of 5:1 or less, stabilized to withstand the passage of heavy equipment, and will provide direct access to the forebay, control structure, and the outlet.

6. When discharge is within a watershed where thermal impacts are a primary concern, deep wet ponds with bottom draw or dry ponds may be preferred. In addition for extended dry detention ponds, first flush and bankfull requirements, may be reduced to 12 hours. See Appendix C, Special Areas of Concern. Shade plantings on the west and south sides of facilities are encouraged. Infiltration of storm water should be considered where site conditions allow.

7. Storage Volumes and Release Rates: On-site management of storm drainage will be designed for control of flooding, downstream erosion and water quality. Submission of flow calculations, cross sections and other pertinent data will be required.

    a. The volume of storage provided for flood control will be equal to or in excess of that required for a 100-year frequency storm as outlined in Appendix H.

        The allowable release rate from the flood control storage volume will normally be between 0.1 and 0.15 cfs per acre of the property being

drained, or as determined by the Drain Commissioner. If discharge does not outlet to a clearly defined downstream channel, it is the developer's responsibility to secure necessary easement(s) from downstream property owner(s).

b. The volume and storage provided for controlling the bankfull flood will be equal to or in excess of the runoff from a 1.5-year, 24-hour storm, which can be determined by:

$$\frac{8170 \times \text{acreage} \times \text{the relative imperviousness factor C}}{}$$

The release rate from the bankfull storage volume will be such that this volume will be stored not less than 24 nor more than 48 hours.

c. The first flush volume of runoff will be captured and detained for at least 24 hours or within a permanent pool. This volume is determined by the runoff from 0.5 inches of rain per acre of the land tributary to the basin. This volume can be determined by:

$$\frac{1815 \times \text{acreage} \times \text{the relative imperviousness factor C}}{}$$

8. Sediment forebays will be provided at the inlet of all storm water management facilities, to provide energy dissipation and to trap and localize incoming sediments.

   a. The forebay will be a separate basin, which can be formed by gabions, a compacted earthen berm, or other suitable structure.

   b. The capacity of the forebay will be equivalent to 5% of the 100-year storm volume based on the area tributary to the inlet.

   c. Exit velocities from the forebay shall not be erosive during the 1.5-year design storm.

   d. Direct maintenance access to the forebay for heavy equipment will be provided.

   e. A permanent vertical depth marker will be installed in the forebay to measure sediment deposition over time. Storm water system maintenance plans will require that sediment be removed when sediment reaches a depth of equal to 50% of the depth of the forebay or 12 inches, whichever is less. See PART 2, Section XIII regarding maintenance plans.

   f. An adequate area for temporary staging of spoils, prior to ultimate disposal, will be provided. This area will be protected such that no runoff will be directed back into the storm water management system or onto private property. For subdivisions and site condominiums, an easement dedicated to the Drain Commissioner or other governmental agency with long-term maintenance responsibility must be provided over the staging area.

9. Basin Inlet/Outlet Design

   a. Velocity dissipation measures will be incorporated into basin designs to minimize erosion at inlets and outlets, and to minimize the resuspension of pollutants.

b. To the extent feasible, the distance between inlets and outlets will be maximized. The length and depth of the flow path across basins and marsh systems can be maximized by:

(1) Increasing the length to width ratio of the entire design

(2) Increasing the dry weather flow path within the system to attain maximum sinuosity

If possible, inlets and outlets should be offset at opposite longitudinal ends of the basin.

c. Ponds with a dry pilot channel shall have a french drain located 2 to 3 feet below the riprap to prevent excessive warming of storm water during periods of low flow.

d. The use of dual outlets, risers, V-notched weirs or other designs that assure an appropriate detention time for all storm events is required.

e. The outlet will be well protected from clogging. A reverse slope submerged orifice or a hooded, broad crested weir are recommended options. If a reverse-slope pipe is used, an adjustable valve may be necessary to regulate flows.

f. Where a pipe outlet or orifice plate is to be used to control discharge, it will have a minimum diameter of 4 inches. If this minimum orifice size permits release rates greater than those specified in these rules, an alternative outlet design that incorporates self-cleaning flow restrictors will be required. Examples include perforated risers and "V" notch orifice plates that provide the required release rate. Calculations verifying this rate will be submitted to the Drain Commissioner for approval.

g. Any backwater effects on the outlet structure caused by the downstream drainage system will be evaluated when designing the outlet.

h. Riser Design

(1) Inlet and outlet barrels and risers will be constructed of reinforced concrete or corrugated metal. Plastic is not acceptable as a riser material. The minimum diameter for riser pipes shall be 24". Riser pipes greater than 4 feet in height shall be 48” in diameter.

(2) Riser pipes shall be set into a cast-in-place concrete base or properly grouted to a pre-cast concrete base. All riser pipes constructed of material other than concrete must be set into a cast-in-place base.

(3) All orifice configurations shall consist of the minimum number of holes with the largest diameter that meet the detention requirements.

(4) A gravel filtration jacket consisting of 3” washed stone and 1” washed stone shall be placed around all riser pipes. The orifice configuration shall be wrapped with hard wire of an appropriate opening size to prevent any stone from passing through the orifice. The 3” stone shall be placed immediately adjacent to the riser pipe

with the 1” stone covering the larger stone. The gravel jacket shall extend sufficiently above all orifice patterns.

(5) Orifices used to maintain a permanent pool level should withdraw water at least one foot below the surface of the water.

(6) Hoods or trash racks shall be installed on the riser to prevent clogging. Grate openings shall be a maximum of three inches on center.

(7) The riser shall be placed near or within the embankment, to provide for ready maintenance access.

(8) Where feasible, a drain for completely de-watering wet ponds should be installed for maintenance purposes.

(9) All outlets will be designed to be easily accessible for heavy equipment required for maintenance purposes.

10. Protection of Receiving Waters

a. Flared end sections are required.

b. In the case of environmentally sensitive riparian zones, a step pool arrangement shall be used to convey the discharge to the stream.

c. The channel immediately below the pond outlet shall be modified to prevent erosion and conform to the natural dimensions in the shortest possible distance.

d. A stilling basin or other measure shall be incorporated to prevent erosive velocities of outflow.

11. Storm water management systems incorporating pumps shall not be permitted in developments with multiple owners, such as subdivisions and site condominiums. Variance requests, submitted in accordance with PART 1, Section VI of these standards, will be considered on a case-by-case basis. However, variances from this rule will be considered only as a measure of last resort, subsequent to demonstration that no alternative system designs are feasible. Special requirements, such as the establishment of an operations/maintenance/replacement account by the Developer, will be imposed to help defray special assessments that would be levied upon future property owners for maintenance of the system.

12. In-line detention basins are strongly discouraged in all circumstances, and are prohibited on watercourses greater than 2 square miles upstream or on a County drain. In-line basins are also prohibited if the waterway to be impounded traverses any area outside of the proposed development.

13. The placement of retention/detention basins within a 100-year floodplain is prohibited. Any appeal to this prohibition must be accompanied with adequate information that verifies that the facility will meet the requirements of these rules during flood events.

14. Anti-seep collars should be installed on any piping passing through the sides or bottom of the basin to prevent leakage through the embankment.

15. A minimum of one foot of freeboard will be required above the 100-year storm water elevation on all detention/retention facilities.

16. All basins will have provisions for a defined emergency spillway, routed such that it will flow unobstructed to the main outflow channel.

    a. The emergency spillway elevation will be set at the elevation of the maximum pond design volume.

    b. The spillway will be sized to pass the maximum design flow tributary to the pond.

17. Vegetative Plantings Associated with Retention/Detention Facilities

    a. Basins and marsh designs will be accompanied by a landscaping plan that incorporates plant species native to the local region and indicates how aquatic and terrestrial areas will be vegetated, stabilized and maintained. See Appendix R for a list of native species.

    b. Whenever possible, native wetland plants should be encouraged in the pond design, either along the aquatic bench, fringe wetlands, safety shelf and side slopes or within the shall areas of the pools.

    c. A permanent buffer strip of natural vegetation extending at least 25 feet in width beyond the freeboard elevation will be maintained or restored around the perimeter of all storm water storage facilities. No lawn care chemicals shall be applied to the buffer area. This requirement will be cited in the subdivision restrictions or master deed documents.

    d. Viability of plantings will be monitored for two years after establishment by the proprietor, and reinforcement and replacement plantings provided as needed.

18. Requirements for storm water quantity control may be waived for developments in the downstream-most locations of a watershed, although quality management will still be necessary. Determinations will be made on an individual site basis.

19. Additional water quality measures will be installed at sites where land uses are identified as pollutant hotspots. See Appendix E.

20. For sites where chemicals may be stored and used, such as certain commercial and industrial developments, a spill response plan will be developed that clearly defines the emergency steps to be taken in the event of an accidental release of harmful substances that may migrate to the storm water system. As a result of this plan, design elements such as shut-off valves or gates may be needed.

B. Permanent Retention Ponds

1. Retention basins with no outlet will be capable of storing two consecutive 100-year storms, which can be determined by:

   $$\frac{33{,}000 \times \text{acreage} \times \text{the relative imperviousness factor C}}{}$$

2. An overflow assessment will be required. The assessment will include descriptions of the surrounding areas that would be impacted in the event of an overflow.

3. The proprietor must submit a soil boring log, taken within the basin bottom area to a depth of 25 feet below existing ground or 20 feet below proposed basin bottom elevation. Information regarding the seasonal groundwater elevations must also be provided.

4. The volume required may be modified based upon the percolation rate of the soil, groundwater elevation and supporting data prepared by a registered professional engineer or certified professional geologist.

C. Wet Detention Basins

1. Storage volume on a gravity outflow wet basin is defined as, "the volume of detention provided above the invert of the outflow device." Any volume provided below the invert of the outflow device will not be considered as detention.

   At a minimum, the volume of the permanent pool should be at least 2.5 times the first flush volume:

   $$\frac{4540 \times \text{runoff coefficient} \times \text{site drainage area}}{}$$

2. Wet detention pond configuration will be as follows:

   a. Surface area to volume ratio should be maximized to the extent feasible.

   b. In general, depths of the permanent pool shall be varied and average between 3 and 6 feet.

   c. A minimum length to width ratio of 3:1 shall be used unless structural measures are used to extend the flow path.

   d. Ponds shall be wedge-shaped, narrower at the inlet and wider at the outlet. Irregular shorelines are preferred.

   e. A marsh fringe shall be established near the inlet and forebay and around at least 50% of the pond's perimeter.

   f. A shelf, a minimum of 4 feet wide at a depth of one foot, will surround the interior of the perimeter to provide suitable conditions for the establishment of aquatic vegetation, and to reduce the potential safety hazard to the public.

   g. To avoid drawdown, a reliable supply of baseflow and/or groundwater will be required.

D. Extended Detention Basins

A two-stage design is required; with separate outlet controls to detain both the 1.5-year and larger rain events.

1. The lower stage shall contain a shallow, permanent pool designed to store and treat the first flush volume, or the runoff from 0.5 inch of rain over the entire site.

    a. This pool shall be managed as a shallow marsh or wetland, and average 6-12 inches in depth.

    b. At a minimum, the volume of runoff detained in the entire lower stage shall be equivalent to the runoff volume produced by a1.5-year storm.

2. The upper stage shall be sized for the 100 year, 24 hour storm, as provided in PART 2 Section II, A.2.i.1 of these rules, and shall be graded to remain dry except during large storms.

    a. A low flow channel, stabilized against erosion, will be provided through the dry portion of the basin. This channel should have a minimum grade of 0.5%, and the remainder of the basin should drain toward this channel at a grade of at least 1%.

    b. The low flow channel should end at the lip of the lower stage, where riprap or gabion baffles will be placed, to prevent scour and resuspension.

E. Storm Water Wetland Systems

Storm water wetlands are defined as constructed systems explicitly designed to mitigate the storm water quality and quantity impacts associated with development. They do so by temporarily storing storm water runoff in shallow pools that create growing conditions suitable for emergent and riparian wetland plants. The runoff storage, complex microtopography and emergent plants in the storm water facilities that couple ponds and constructed wetlands together form an ideal system for the removal of urban pollutants. Because of their water quality benefits, the use of storm water wetlands is encouraged.

1. As a general rule, storm water wetlands may not be located within delineated natural wetland areas, nor within created wetlands that are used to mitigate the loss of natural wetlands.

2. The design of an effective and diverse storm water wetland requires a sophisticated understanding of hydrology and wetland plant ecology. Therefore, a qualified professional with specific wetland expertise must oversee wetland construction, re-construction or modification.

3. Storm water wetland systems must be designed to perform in conformance with all standards for storage volume and discharge rate established in these rules.

4. The proprietor will provide for the monitoring of wetland plantings and replacement as needed for a two-year period after construction.

STORM WATER CONVEYANCE

A All structures will be constructed in accordance with governing specifications including Michigan Department of Transportation, Washtenaw County Road Commission, and the City or Township. In the event of no other governing specifications, the latest edition of the Michigan Department of Transportation standards will be observed.

B. Storm water conveyance systems incorporating pumps shall not be permitted in developments with multiple owners, such as subdivisions and site condominiums.

C. Natural Streams and Channels

5. Natural streams are to be preserved. Natural swales and channels should be preserved, whenever possible.

6. If channel modification must occur, the physical characteristics of the modified channel will duplicate the existing channel in length, cross-section, slope, sinuosity, and carrying capacity.

7. Streams and channels will be expected to withstand all events up to the 100-year storm without increased erosion. Armoring banks with riprap and other manufactured materials will be accepted only where erosion cannot be prevented in any other way, such as by the use of vegetation.

D. Vegetated Swales/Open Ditches

Open swale/ditch drainage systems are preferred to enclosed storm sewers where applicable governmental standards and site conditions permit.
Swales will be required to:

a. Follow natural, pre-development drainage paths insofar as possible.

b. Be well vegetated, wide and shallow.

8. Open ditch flow velocities will be neither siltative nor erosive. The minimum acceptable velocity will be 2.0 ft./sec., and the maximum acceptable velocity will be 6.0 ft./sec.

9. Open ditch slopes will depend on existing soils and vegetation. However the minimum acceptable slope is 1.5 %, unless other techniques such as infiltration devices are implemented. Maintenance for such devices must be detailed in the overall maintenance plan.

10. Side slopes of ditches shall be no steeper than 3:1. Soil conditions, vegetative cover and maintenance ability will be the governing factors for determining side slope requirements.

11. Slopes and bottoms of open ditches and swales will be stabilized to prevent erosion.

12. Swale length shall be a minimum of 200 feet whenever possible, to increase the contact time of storm water. The maximum length will be based on soil type, slope and catchment area.

13. A minimum clearance of 5 feet is required between open swale/ditch inverts and underground utilities unless special provisions are employed. Special

provisions, for example, could be the encasement of utility lines in concrete when crossing under the channel. In no case will less than 2 feet of clearance be allowed.

14. Permanent metal or plastic markers will be placed on each side of the drain to show the location of underground utilities.

15. All bridges will be designed to provide a 2-foot minimum flood stage freeboard to the underside of the bridge. Footings will be at least one foot below the invert grade of the channel. Depending on soils, additional footing depth may be required.

16. A series of check dams or drop structures across swales shall be provided to enhance water quality performance and reduce velocities.

17. Designers should consider integrating additional redundant pollutant removal enhancement features such as stilling basins and stone infiltration trenches.

E. Enclosed Drainage Structures

18. Enclosed storm drain systems will be sized to accommodate the 10-year storm, with the hydraulic gradient kept below the top of the pipe.

19. Restricted conveyance systems designed to create backflow into storm water storage facilities are not permitted.

20. Drainage structures will be located as follows:

    a. To assure complete positive drainage of all areas of the subdivision.

    b. At all low points of streets and rear yards.

    c. Such that there is no flow across a street intersection.

    d. For smaller enclosed pipes, 12 to 24 inches in diameter, manholes will not be spaced more than 400 feet apart. Longer runs may be allowed for larger sized pipe but in all cases maintenance access must be deemed adequate by the Drain Commissioner.

21. The catch basin or inlet covers shall be designed to accept the 10-year design storm. No ponding of water should occur during this storm event.

22. Discharge from enclosures will be as follows:

    a. All outlets will be designed so that velocities will be appropriate to, and will not damage, receiving waterways.

    b. Outlet protection using riprap or other approved materials will be provided as necessary to prevent erosion.

    c. The soils above and around the outlet will be compacted and stabilized to prevent piping around the structure. Riprap extending 3 feet above the ordinary high water mark is required for all outlets.

    d. When the outlet empties into a detention/retention facility, channel or other watercourse, it will be designed such that there is no free overfall from the end of the apron to the receiving waterway.

23. Pipe will conform to the following criteria:

a. The minimum pipe acceptable pipe diameter is 12 inches.

b. In order to avoid accumulation of sediment in the drain, pipe will be designed to have minimum velocity flowing full of 3 ft/sec., with the exception of sediment chambers.

c. The maximum allowable velocity flowing full will be 10 ft/sec.

d. Pipe joints will be such as to prevent excessive infiltration or exfiltration.

e. All materials will be of such quality as to guarantee a maintenance-free expectancy of at least 50 years and will meet all appropriate A.S.T.M. standards.

f. The minimum depth of pipe shall be 42 inches from grade to the springline of the pipe.

24. In areas where local ordinance requires sump pump leads to be connected into an enclosed system, these taps shall be made directly into storm sewer structures or into cleanouts approved by the Drain Commissioner's Office.

25. Sump pump lines and connections shall not fall under the long term operation and maintenance of the Drain Commissioner's Office and will not become part of an established county drain. Maintenance of such lines will be the responsibility of the property owners, and should be so specified in subdivision rules or condominium master deed agreements.

F. Channel/Pipe Design

1. Manning's formula will be used to size the open channel or pipe. See Table 2 below for roughness coefficients.

$$Q = \frac{1.486}{n} AR^{2/3} S^{1/2}$$

2. A minimum "n" of 0.035 will be used for the roughness coefficient for open channels, unless special treatment is given to the bottom and side slopes, such as sodding, riprap or paving.

3. If Manning's equation is not used, the Drain Commissioner shall approve the alternative method used.

Table 2. Manning Roughness Coefficients for Various Surfaces

Boundary Material	n value	Boundary Material	n value
HDPE pipe, smooth lined	0.011	Brick	0.016
Concrete pipe	0.013	Riveted steel	0.018
Vitrified clay pipe	0.014	Rubble	0.025
Cast iron pipe	0.015	Gravel	0.029
HDPE pipe, unlined	0.018	Riprap	0.033
Finished concrete	0.012	Natural channels in good condition	0.025
Planed wood	0.012	Natural channels with stones & weeds	0.035
Unplaned wood	0.013	Natural channels in poor condition	0.060
Unfinished concrete	0.014	Natural channels with heavy brush	0.100

G. Culvert Design

1. Under Michigan State Law, Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, crossroad culverts draining two square miles or more must be reviewed and approved by the Michigan Department of Environmental Quality.

2. Crossroad culverts draining less than 2 square miles of upstream watershed will be sized by the proprietor's engineer and approved by the Washtenaw County Road Commission and Washtenaw County Drain Commissioner's Office.

3. At a minimum, culverts will be designed to convey the peak 10-year storm flow with the velocity not exceeding 8 fps. The 100-year storm must pass the embankment with no adverse increase in water elevation occurring off of the development property or flooding of structures within the development. A minimum of one foot of freeboard is required.

4. Acceptable methods of determining the flowrate required to pass through the culvert are listed below. The proprietor's engineer may use any of the methods listed or another if approved by the Drain Commissioner's Office:

    a. Rational Method

    b. USDA Soil Conservation Service Method

    c. The Michigan Department of Natural Resources Method

    d. Continuous flow modeling

5. The discharge velocity from culverts should consider the effect of high velocities, eddies, or other turbulence on the natural channel, downstream property and roadway embankment. The culvert exit velocity should not cause downstream channel erosion or scour.

6. Sizing of culvert crossings will consider entrance and exit losses as well as tailwater conditions on the culvert. Once the design flow is determined, the required size of the culvert will be determined by one of the following methods:

   a. The "Mannings" formula

   b. The inlet headwater control/outlet tailwater control nomographs

   c. Other methods approved by the Drain Commissioner

7. Wing walls, headwalls and all other culvert extremities will be designed to assure the stability of the surrounding soil. It is recommended that Michigan Department of Transportation standard designs be observed unless special exemption is given.

ADDITIONAL STORM WATER MANAGEMENT BMPs: INFILTRATION FACILITIES AND SAND FILTERS

A variety of best management practices, other than those detailed within these rules, provide effective water quality and quantity control. The following section provides design standards for only two of many approaches acceptable to the Drain Commissioner, presuming site suitability and adequate maintenance provisions. *A reference bibliography is provided at the end of this document (Appendix N).*

A. INFILTRATION FACILITIES

Infiltration devices are designed to capture and treat storm water runoff from smaller rain events, which are managed for water quality purposes. They function to reduce runoff at its source, since the diverted "first flush" is not discharged to surface water but is stored until it is gradually removed by infiltration and evaporation. Through these mechanisms, infiltration can remove pollutants, provide groundwater recharge and help reduce the volume of runoff leaving a site. Infiltration devices are generally incorporated as one component of an overall storm water system that utilizes other management approaches as well.

While the concept of infiltration best conforms to the storm water management goals of water quantity and quality control stated within these rules, in practice, infiltration approaches to storm water management somewhat have limited application. Although many infiltration devices are very effective for removing fine sediment particles and the pollutants associated with them, coarse sediments and oil will clog infiltration systems, and must be removed prior to entering them. Clogging of infiltration devices is a primary reason for failure, causing many to fail during the first few years of operation. The use of erosion control measures, sedimentation basins and grass filter strips to pre-treat runoff is essential, as is a very aggressive maintenance program. In addition, studies have shown that many infiltration facilities fail or do not work as designed due to poor initial site selection. Therefore, soil suitability and the contributing drainage area must be carefully assessed. The potential for groundwater contamination must also be seriously considered prior to implementation.

Infiltration approaches to storm water management are particularly effective for small catchment areas of less than 10 acres in size, and in areas where thermal impact is a primary concern.

1. Site Criteria for Infiltration Facilities

    a. Infiltration facilities will be permitted only on sites with undrained hydrologic soil group classifications of A or B. Where infiltration facilities are proposed, a sufficient number of soil borings will be provided in each location to evaluate the site suitability. See Appendix K for the appropriate classifications.

    b. The maximum tributary area to an individual infiltration facility shall be limited to 5 acres.

    c. Infiltration facilities are not feasible where the slope of the site is greater than 6%, unless proper energy dissipation devices are installed.

    d. Infiltration facilities are also not recommended where the slope of the watershed contributing directly to the device is greater than 5%.

    e. Trenches and underground components will be readily accessible for maintenance purposes.

    f. Infiltration facilities will not be located within 100 feet of a water supply well or a building foundation.

    g. Infiltration facilities will not be built downslope of new construction until the entire development area has been permanently stabilized.

2. Design Criteria for Infiltration Facilities

    a. Minimum design volume will be based on infiltration of 0.5-inch runoff over the entire drainage basin.

    b. All facilities will be designed to hold water for a minimum of 6 hours and a maximum of 72 hours.

    c. The bottom of the device will be a minimum of 4 feet above seasonally high groundwater and bedrock.

    d. To remain operative in freezing weather, the bottom of the device will be placed 12 inches below the frost line.

    e. An observation well, consisting of a perforated vertical pipe within the trench, will be installed in every trench to monitor performance.

    f. The bottom of the infiltration trench will be scarified to a depth of 4”-6”, to reduce the possibility of initial soil compaction caused by excavation with heavy equipment.

    g. The slope of the trench bottom should be close to zero to evenly distribute exfiltration.

    h. Uniform, washed stone a minimum of 1 inch in diameter will be used within the device.

    i. Where an overflow pipe is provided for flows in excess of design, the pipe will be placed near the surface of the trench and outlet to an acceptable point of discharge.

    j. A legally enforceable and binding maintenance agreement will be included for infiltration systems. All systems will require annual inspection and maintenance.

3. Storm water Pre-treatment

    a. Each infiltration facility shall have redundant pre-treatment methods to protect the long-term integrity of the infiltration rate.

    b. A sediment settling basin or other storm water management practice will be provided to remove coarse sediment from storm water flows before they reach infiltration trenches.

    c. For surface trenches, a minimum 25-foot wide grass buffer is required as a filter.

    d. Underground trenches will receive water directed through an oil/grit separator or other form of pre-treatment that will remove both coarse solids and oils.

B. Sand Filters

A sand filter is a storm water treatment devise, whereby the first flush of runoff is diverted into an off-line, self-contained bed of sand. The runoff is then strained through the sand, collected in underground pipes and returned back to the stream or channel. Enhanced sand filters utilize layers of peat, limestone, and/or topsoil, and may also have a grass cover crop. In general, sand filters have a limited ability to reduce peak discharges and are usually designed solely to improve water quality.

Because a sand filter is a self-contained, artificially constructed soil system, it has few constraining factors and can be applied to most development sites, including those too small to be effectively served by ponds (i.e. small infill developments.) Sand filters are also useful in areas with concerns about groundwater contamination and poor soil infiltration rates, and as end-of-pipe retrofits. The upper limit on sand filters appears to be about 50 acres; however, a contributing watershed between 0.5 and 10 acres is recommended.

While the technology is still developing, a number of standard sand filter designs are available and may be acceptable to the Drain Commissioner.

General standards for the design of sand filter systems are as follows:

1. All designs shall incorporate the following three basic components:

    a. A pre-treatment wet pool or sedimentation basin;

    b. An on-line diversion weir for isolating the storm water to be treated

    c. An off-line sand filter bed area.

2. The system should be designed to capture and treat the first 0.5-inch of runoff from the impervious portion of the contributing watershed.

3. Pre-treatment of storm water will be required before discharge into the sand filter. The following pre-treatment mechanisms are acceptable, depending on site-specific considerations:

    a. Wet pools

    b. Sedimentation basins

    c. Oil-grit separators

d. Grass filter strips

4. Sufficient sediment storage volume will be provided within pre-treatment devices, so that clean-out intervals are reduced to once every 2 to 3 years.

5. Design storm flows will be conveyed to the sand filter bed basin at a non-erosive velocity. Generally, this velocity will be less than one foot per second.

6. An over-sized perforated hood/trash guard will be incorporated into weir designs to minimize clogging of the baseflow pipe.

7. Excess runoff volumes will be returned to the receiving conveyance channel via a riprapped baseflow/overflow channel.

8. Design of Sand Filter Beds

   a. Several formulas for sizing sand filter beds are available, and may be acceptable to the Drain Commissioner.

   b. The maximum surface ponding time for the design runoff volume will be limited to 24 hours.

   c. An impermeable liner may be required to eliminate potential groundwater infiltration/exfiltration problems.

9. Because of the potential for system failure due to bed clogging, sand filter system use is restricted to stabilized drainage areas.

10. Regular inspection and timely periodic removal of sediment and trash will be required. Grass cover crops, when provided, will be mowed whenever they exceed 10 cm. height (approx. once per week) and all grass cuttings removed.

11. The filter bed area will be clearly marked, and an appropriate drainage easement provided.

III. NATURAL WETLANDS

This section governs natural wetlands (as distinct from storm water wetland systems that are constructed expressly for storm water management purposes), when a natural wetland is incorporated in an overall storm water management scheme.

A. Wetlands will be protected from damaging modification and adverse changes in runoff quality and quantity associated with land developments. Before approval of the final plan, all necessary wetland permits from the MDEQ and local governments will be in place.

B. Direct discharge of untreated storm water to a natural wetland is prohibited. All runoff from the development will be pre-treated to remove sediment and other pollutants prior to discharge to a wetland. Such treatment facilities will be constructed before property grading begins.

C. Site drainage patterns will not be altered in any way that will modify existing water levels in protected wetlands without proof that all applicable permits from the MDEQ and/or local government agencies have been obtained.

D. A qualified professional with specific wetland expertise will oversee wetland construction, re-construction, or modification.

E. Whenever possible, a permanent buffer strip, vegetated with native plant species, will be maintained or restored around the periphery of wetlands. See Appendix R.

F. Wetlands will be protected during construction by appropriate soil erosion and sediment control measures.

IV. LOT GRADING

Approval of final lot grading is the responsibility of the local municipality. The Drain Commissioner's office is not responsible for inspection of, or enforcing corrections to, final lot grading. It is the Drain Commissioner's responsibility to ensure that the overall plan is consistent with sound storm water management and drainage practices. The subdivision storm water management plan will provide for the following:

A. The grading of lots will be such that surface runoff is away from homes and toward swales, ditches or drainage structures. Provision for drainage through properly graded storm water conveyance systems will be made for all areas within the proposed subdivision.

B. Where finished grades indicate a substantial amount of drainage across adjoining lots, a drainage swale of sufficient width, depth and slope will be provided on the lot line to intercept this drainage. To ensure that property owners do not alter or fill drainage swales, easements will be required over areas deemed necessary by the Drain Commissioner, as stipulated in PART 2, Section XI.

V. SOIL EROSION, SEDIMENTATION AND POLLUTION CONTROL

Discharge of sediment or other polluting materials to a waterway that is under jurisdiction of the Drain Commissioner, either within or outside of the subdivision, will be considered pollution to a county drain, and hence a violation of section 280.423 of the Michigan Drain Code. Under the Michigan Drain Code, pollution of a county drain is a criminal misdemeanor, punishable by fine of $25,000 or imprisonment.

A. SOIL EROSION/SEDIMENTATION CONTROL

All erosion control measures will be regularly inspected and maintained.

1. During Construction

   a. The development plan shall fit the topography and soil so as to create the least erosion potential.

   b. An approved soil erosion permit from the local enforcing agent, as well as a National Pollution Discharge Elimination System (NPDES) permit where applicable, will be required.

   c. Sediment shall not be permitted to leave the site. Recommended procedures to achieve this goal are as follows:

(1) Wherever feasible, natural vegetation should be retained and protected.

(2) The smallest practical area of raw land should be exposed at any one time (i.e. only areas under active construction).

(3) The entire site should be planted with temporary vegetation immediately after mass grading operations.

(4) Temporary vegetation and/or mulching should be used to protect critical areas exposed during development.

(5) Sediment basins where needed should be installed and maintained by the proprietor.

(6) The permanent, final vegetation and structures should be installed as soon as practicable in the development.

d. Areas within open drain easements that have been cleaned, reshaped or disturbed in any manner will be stabilized with seed and mulch or sod as quickly as possible.

e. All storm sewer facilities that are or will be functioning during construction will be protected, filtered, or otherwise treated to prevent sediment from entering the system. Construction activities will be complete before the construction of any storm water management facilities susceptible to clogging such as infiltration devices.

2. Permanent Erosion Control Measures

a. Before entering any natural watercourse, protected wetland, county drain or other body of water, best management practices will be utilized to remove pollutants, including sediment, from storm water runoff. Pollutant removal methods will include capture and treatment of the first flush and bankfull storm events, as previously described in these standards. In addition, receiving waters shall be protected as previously described.

b. Permanent erosion protection will be placed at bends, drain inlets and outlets, and other locations as needed in all open ditches. Headwalls, grouted riprap, soil bioengineering methods, or other stabilization measures will be provided where necessary to prevent erosion.

c. Outlets to ditches will be placed at the average low water elevation of the watercourse. Outlet velocities will be non-erosive.

d. Ditches with steep grades or unstable soils will be protected by sod, vegetative erosion control, geotextile fabric, riprap or other means to prevent scour.

e. All detention/retention basins will be permanently stabilized to prevent erosion.

B. OTHER POLLUTION CONTROL

1. Discharge of runoff that may contain oil, grease, toxic chemicals, or other polluting materials is prohibited. Measures will be employed to reduce and trap pollutants and meet any prevailing federal, state, or local water quality requirements.

2. In commercial and industrial developments where large amounts of oil and grease may accumulate, appropriate methods for separating pollutants will be required. When used, oil and grit separator will be installed off-line or in locations where flow velocities have been determined to be lower than scouring velocity in a 10-year storm. Where such facilities are proposed, a maintenance program, including an identified method and site for waste disposal, is required.

3. For sites where chemicals may be stored and used (e.g. certain commercial and industrial developments) a spill response plan must be developed that clearly defines the emergency steps to be taken in the event of an accidental release of harmful substances to the storm water system.

4. Structures designed to remove trash and other debris from storm water will be installed as required on storm water management facilities prior to their outlet.

5. Additional water quality protection measures may be required depending on the nature and location of the development and the receiving waters.

VI. BUFFER STRIPS

A. Buffer strips are defined as zones where construction, paving, and lawn care chemical applications are prohibited.

B. Buffer strips shall be established adjacent to all surface waters through deed restrictions or provisions of condominium master deed documents.

C. Plantings capable of filtering storm water shall be preserved or established.

D. The minimum width shall be 25 feet measured from the top of bank.

VII. FLOODPLAINS

A. It is the responsibility of the developer to demonstrate that any activity proposed within a 100-year floodplain will not diminish flood storage capacity.

B. In certain instances an analysis to determine the 100-year floodplain may be required. Where available, the community flood insurance study shall be used.

C. Compensatory storage will be required for all lost floodplain storage.

VIII. EASEMENTS

A. Wording relative to easement information will be as specifically required by the Drain Commissioner's Office. If a county drain is to be established under the Michigan Drain Code, related easement language will be depicted on final mylar plats and condominium exhibit B drawings as follows:

" ____ foot wide private easement to Washtenaw County Drain Commissioner and the _____ Homeowner's (or Condominium) Association for drainage."

B. The typical easement language as specified in Appendix L will be included in the subdivision deed restrictions or condominium master deed.

C. The location and purpose of drainage easements should be clearly described in subdivision deed restrictions or condominium master deeds.

Language will be included within the subdivision deed restriction or condominium master deed that clearly notifies property owners of the presence storm water management facilities and accompanying easements, as well as restrictions on use or modification of these areas.

D. If a utility is to be located within the right-of-way of any county drain or drainage easement, it will be located such that it will not increase the expense of maintaining the drainage facility.

E. Retention/detention basins or other storm water management facilities will have sufficient easements for maintenance purposes. Easements will be sized and located to accommodate access and operation of equipment, spoils deposition, and other activities identified in the development's storm water system maintenance plan.

F. Easement widths will be determined by the Drain Commissioner and be situated in such a way as to allow maximum maintenance access, for example, offsetting them from the centerline. In general, easement widths will conform to the following:

1. Open channels and watercourses: A minimum of 50 feet total width. Additional width may be required in some cases, including but not limited to: watercourses with floodplains delineated by FEMA; sandy soils, steep slopes, at access points from road crossings.

2. Open swales (cross lot drainage): minimum of 30 feet total width.

3. Enclosed storm drains: A minimum of 20 feet will be required, situated in such a way as to allow maximum maintenance access. Additional width will be required in some cases. These may include but are not limited to, pipe depths exceeding 4 feet from the top of pipe, sandy soils and steep slopes.

G. Drain fields (septic areas) shall not be located within drainage easements.

IX. SAFETY CONSIDERATIONS

A. Drainage system components, especially all ponds, will be designed to protect the safety of all persons coming in contact with the system. The following criteria will apply:

1. The side slopes of all detention basins should not exceed 5H:1V, and will be as gradual as practicable to prevent accidental falls into the basin and for stability and ease of maintenance.

    a. If steeper slopes are proposed, continuous fencing at least 5 feet in height with gates at least 12 feet wide for access by emergency and or maintenance vehicles shall be provided.

    b. An area at least 12 feet in width around the basin shall be provided inside of the fencing for maintenance equipment.

    c. Fencing materials shall meet with the approval of the Drain Commissioner.

2. Side slopes of open channels will not be steeper than 3:1.

3. Velocities throughout the surface drainage system will be controlled to safe levels taking into consideration rates and depths of flow.

4. All wet detention basins will have a level safety ledge at least 4 feet in width and one foot below the normal water depth, and other design and landscaping features as may be needed to provide for protection of the public.

X. STORM WATER MANAGEMENT SYSTEM MAINTENANCE PLANS

A. Maintenance plans will be submitted with all construction plans and included in the subdivision agreement or master deed documents of all subdivisions and site condominiums. These plans shall include the following information:

1. An annual maintenance budget itemized in detail by task. The financing mechanism shall also be described.

2. A copy of the final approved drainage plan for the development that delineates the facilities and all easements, maintenance access, and buffer areas.

3. A listing of appropriate tasks defined for each component of the system described, and a schedule for their implementation. The following areas will be covered:

    a. Maintenance of facilities such as pipes, channels, outflow control structures, infiltration devices and other structures.

    b. Debris removal from catch basins, channels and basins.

    c. Dredging operations for both channels and basins to remove sediment accumulation. Storm water system maintenance plans shall require that sediment be removed when sediment reaches a depth of equal to 50% of the depth of the forebay or 12 inches, whichever is less.

4. The party responsible for performing each of the various maintenance activities described, which will be recorded with final approved plans and plats.

5. A detailed description of the procedure for both preventative and corrective maintenance activities. The preventative maintenance component will include:

    a. Periodic inspections, adjustments and replacements.

    b. Record-keeping of operations and expenditures.

6. Provision for the routine and non-routine inspection of all components within the system described:

    a. Wet weather inspections of structural elements and inspection for sediment accumulation in detention basins, shall be conducted annually, with as-built plans in hand. These should be carried out by a professional engineer reporting to the responsible agency or owner.

    b. Housekeeping inspections, such as checking for trash removal, should take place at least twice per year.

    c. Emergency inspections on an as-needed basis, upon identification of problems, should be conducted by a professional engineer.

7. A description of ongoing landscape maintenance needs. Landscaping shall consist of low maintenance and/or native plant species. The proprietor will monitor the viability of plantings for at least two years after establishment and plantings will be replaced as needed. Subsequent monitoring shall be conducted by the landowner or development association. The Drain Commissioner is not responsible for landscape maintenance.

8. Provision for the maintenance of vegetative buffers by landowner, development associations, conservation groups or public agencies. Buffers must be inspected annually for evidence of erosion or concentrated flows through or around the buffer.

B. All Infiltration systems must be aggressively maintained and protected from clogging by sediment.

    1. In the event of clogging by accumulated sediments, partial or total reconstruction of infiltration facilities may be required.

    2. Porous pavement shall be vacuum swept and jet hosed at least four times per year to remove any grit or sediment trapped in the pores of the open-graded asphalt.

    3. Evidence of a regular service contract for performing this activity will be required.

C. Property deed restrictions or condominium master deed documents will specify the timeframe for action to address needed maintenance of storm water management facilities. These restrictions or documents will also specify that, should the private entity fail to act within this timeframe, the responsible governmental entity may perform the needed maintenance and assess the costs against the property owners within the subdivision or condominium association:

1. Routine maintenance of storm water management facilities will be completed per the schedule submitted with the construction plans or within 30 days of receipt of written notification by the responsible governmental entity that action is required, unless other acceptable arrangements are made with the supervising governmental entity.

2. Emergency maintenance will be completed within 36 hours of written notification unless threat to public health, safety and welfare requires immediate action.

D. The proprietor may fulfill the obligation to ensure that a governmental entity will be responsible for drainage system maintenance by establishing a county drainage district, or any other similar mechanism approved by the Drain Commissioner, to provide for the permanent maintenance of storm water management facilities and necessary funding.

E. If a County Drain is not established, the proprietor will submit evidence of a legally binding agreement with another governmental agency responsible for maintenance oversight.

F. A legally binding maintenance agreement will be executed before final project approval is granted. The agreement shall be included in the property deed restrictions or condominium master deed documents so that it is binding on all subsequent property owners.

G. A sample maintenance plan and annual budget is illustrated in Appendix P.